Incident Summary #II-754551-2018 (#9026) (FINAL)

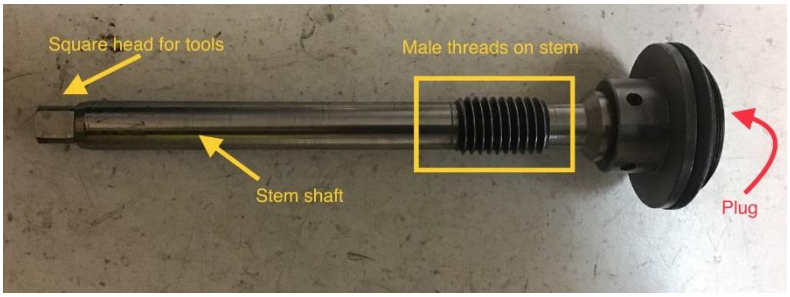
SUPPORTING INFORMATION	Incident Date		October 9, 2018
	Location		Abbotsford, BC
	Regulated industry sector		Boilers, PV & refrigeration - Refrigeration system
	Impact – Injury	Qty injuries	0
		Injury description	None
		Injury rating	None
	Impact – Damage	Damage description	A high pressure ammonia line valve failed, releasing approximately 350 pounds of ammonia vapours into the machinery room.
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		Approximately 350 pounds of ammonia was released into the machinery room when a mechanic was working on a refrigeration system and the high pressure ammonia line valve failed. All released vapors were vented to atmosphere through the exhaust system.
INVESTIGATION CONCLUSIONS	Site, system and components		A poultry processing facility processes and stores meat. In order to avoid deterioration, sub-zero temperatures are required to quick-freeze and blast chill the meat. Blast chilling is a method of cooling food quickly to a low temperature that is relatively safe from bacterial growth. Bacteria multiply fastest between +8°C (46°F) and +68°C (154°F). The blast chilling is done at -200°F (-128°C) and meat is stored in warehouses at -8°F (-22°C) after processing. Refrigeration equipment is required to produce such low temperatures. Ammonia is an ideal industrial refrigerant for large plants such as cold storages, food processing, packing plants, because it is inexpensive, and is very efficient. Ammonia is toxic and can be a hazard to human health. At higher concentrations, it can cause death. The refrigeration system containing ammonia is almost entirely installed inside a separate machinery room. To get desired low temperatures, a compression refrigeration system comprising of compressors, electric motors, metallic pressure vessels (PV), interconnecting metallic pressure piping, and valves are used. An electric motor runs the compressor. In turn, the compressor compresses refrigerant vapors. The pressure vessels store, contain and transfer ammonia liquid or vapor at various stages of refrigeration process. The valves and fittings regulate fluid flow/direction and makes possible, system isolation for maintenance. Altogether, this system forms a pressure boundary which allows for safe processing of refrigerant. A pressure boundary is breached and refrigerant leaks into nearby surrounding as a result of failure of any of the refrigerant component, for example a leak developed in a valve. The function of the high pressure receiver (HPR) is to provide storage for part of the ammonia liquid inventory needed to supply the plant refrigeration loads. The liquid ammonia enters from the HPR into an inter-cooler where it cools down before being sent to other components of the refrigeration system. There must be continuous supply of liquid ammonia to other parts of the refrigeration system, in order to maintain the desired cooling.

Incident Summary #II-754551-2018 (#9026) (FINAL)

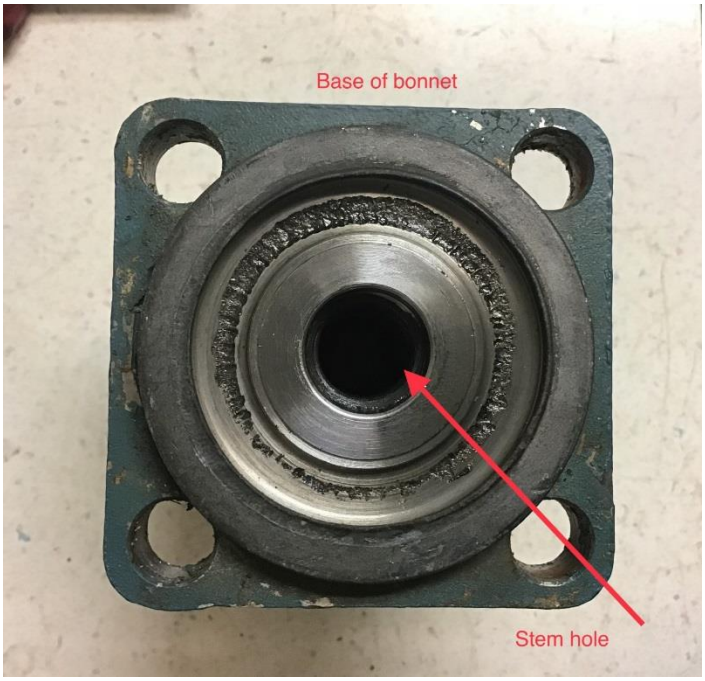
	A shut off valve, which can be manually operated, is installed on piping that enters the inter-cooler. The function of this valve is to regulate the amount of liquid ammonia entering into the inter-cooler. The valve consists of a bonnet, stem & plug, packing nut & seal cap. The stem is threaded externally only on its middle portion, whereas the bonnet is threaded internally. The stem has a square head that can be turned using a wrench and it can be moved up and down to regulate the flow. There is a plug attached to the end of stem and this plug sits onto its seat. When the plug sits completely onto its seat, no flow of liquid can take place across the valve. The packing nut is the part of the valve that provides a tight seal around the valve stem. The packing nut on a shut-off valve can leak. Refer to photographs attached.
Failure scenario(s)	On October 8, 2018 in the morning, a licensed refrigeration mechanic was working on this site and closed off the shut off valve on the inter-cooler. After completion of his work, he tried to open the shut off valve again. He noticed the stem was freely rotating. The mechanic was not sure why this happening. He thought that the plug might have broken and fallen off of the end of stem assembly. The mechanic logged it into logbook and left the site for the day. On the night of October 9, 2018, the night shift operator noticed a significant increase in temperatures in the blast chiller (-20°C to -9°C). He informed the maintenance supervisor early the next morning about this at 5:30 am. On morning of October 9, 2018, the maintenance supervisor started trouble shooting by checking the ammonia level in vessel V1 and found a significant drop in levels. An electric controller in the refrigeration system was indicating low levels of ammonia in vessel V1. Due to these low levels of refrigerant the downstream pump was automatically turned off to avoid damage to it. This all was resulting in a temperature increase in the system. Tracing the problem of low ammonia liquid supply upstream, the maintenance supervisor reached inter-cooler and found the stem on the inlet shut off valve was freely spinning. He called a licensed refrigeration mechanic to trouble shoot the faulty valve. This shut off valve was installed in 2015 and is usually held in the open position in the system. A licensed refrigeration mechanic arrived at site at around 6:30 am. He tried to back-seat or close the shut off valve stem with a six inch crescent wrench. The refrigeration system and line was still pressurized. It seemed to the mechanic that the stem threaded portion got disengaged from the internally threaded bonnet or the plug had fallen off from the end of the stem. The mechanic tried to pull the stem up while holding the packing nut with another wrench. At this time the packing nut came out of its position and gushed liquid ammonia into the mechanical room from both sides of the packing nut. The shut off valve failed and approximately 350 pounds of liquid & vapour ammonia was released into the machinery room. The mechanic was wearing a full face respirator at the time of this release. He ran into the plant and informed the maintenance supervisor to call emergency rescue teams. The plant was evacuated. Fire department and HAZMAT team responded within 30 minutes. Refrigeration mechanic was given safety orientation on site and he entered into machinery room accompanied with a member of HAZMAT team, wearing all required safety gear, to contain the leak. The ammonia concentration in machinery room was recorded in the range of 9200-9500 ppm. Forced air fans and ducts were deployed for several hours to disperse and remove remaining ammonia vapors from the machinery room.

Incident Summary #II-754551-2018 (#9026) (FINAL)

	The system ammonia charge pump down started at 3 pm and completed at 8 pm. The stem-plug and bonnet assembly was replaced with a new one. The shut off valve body could not be replaced as it is welded to the piping on both ends.
Facts and evidence	There were two witness accounts. The first was from a refrigeration mechanic working on the system at the time of the leak and the second was the maintenance supervisor of the facility, as follows; The body and bonnet/stem assembly on failed valves were found to be incompatible and not of the correct type. External threaded portion on the replacing stem was longer than the replaced stem. Both mentioned that it is possible that at the time when this shut off valve was originally installed by another licensed refrigeration contactor in 2015 – the body and bonnets were inadvertently mixed up so an incompatible type of bonnet/stem may have been installed on the valve body. They mentioned that mechanics usually use a center punch to mark on the valve body and bonnet so that they will not get mixed up and correct set gets installed. The installation of the incorrect bonnet/stem into the valve prevented the isolation of the ammonia liquid which is what the valve is intended to do. Also when the valve is installed with its stem in vertical position, back seating it becomes difficult as pressurized liquid acts against plug base and forces it upwards. The failed valve was placed into the piping in the opposite direction to that displayed by the direction of flow arrow on the valve. The stem was supposed to be in horizontal position but it was found to be in vertical position. They are not sure why the valve was installed with its stem in vertical position.
Causes and contributing factors	It is probable that the installation of an incompatible bonnet/stem and valve body eventually failed during maintenance and operation allowing ammonia to escape from the system.



Picture 1: Stem and Plug assembly – 1/1/2 inch shut off Ammonia Refrigeration Valve (actual part involved in the incident)

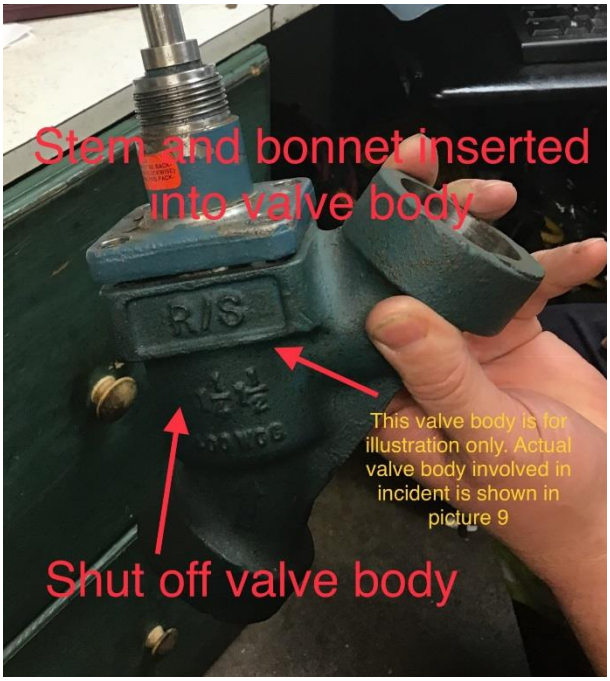


Picture 2: Bonnet base view – 1/1/2 inch shut off Ammonia Refrigeration Valve (actual part involved in the incident)

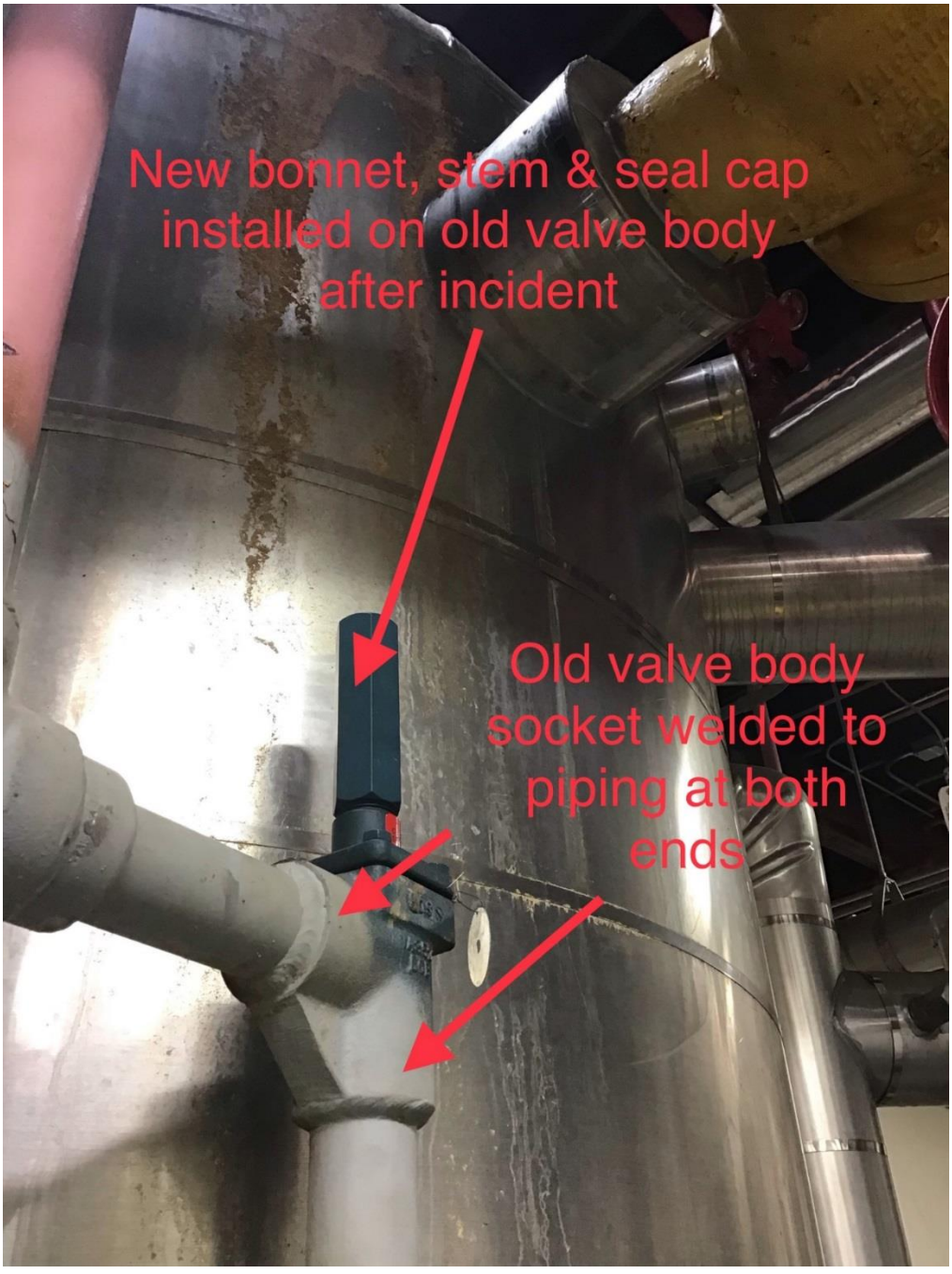
Picture 3: Overall view – 1/1/2 inch shut off Ammonia Refrigeration Valve (actual part involved in the incident)

Picture 4: Bonnet base – internal threads shown on stem home (actual part involved in the incident)

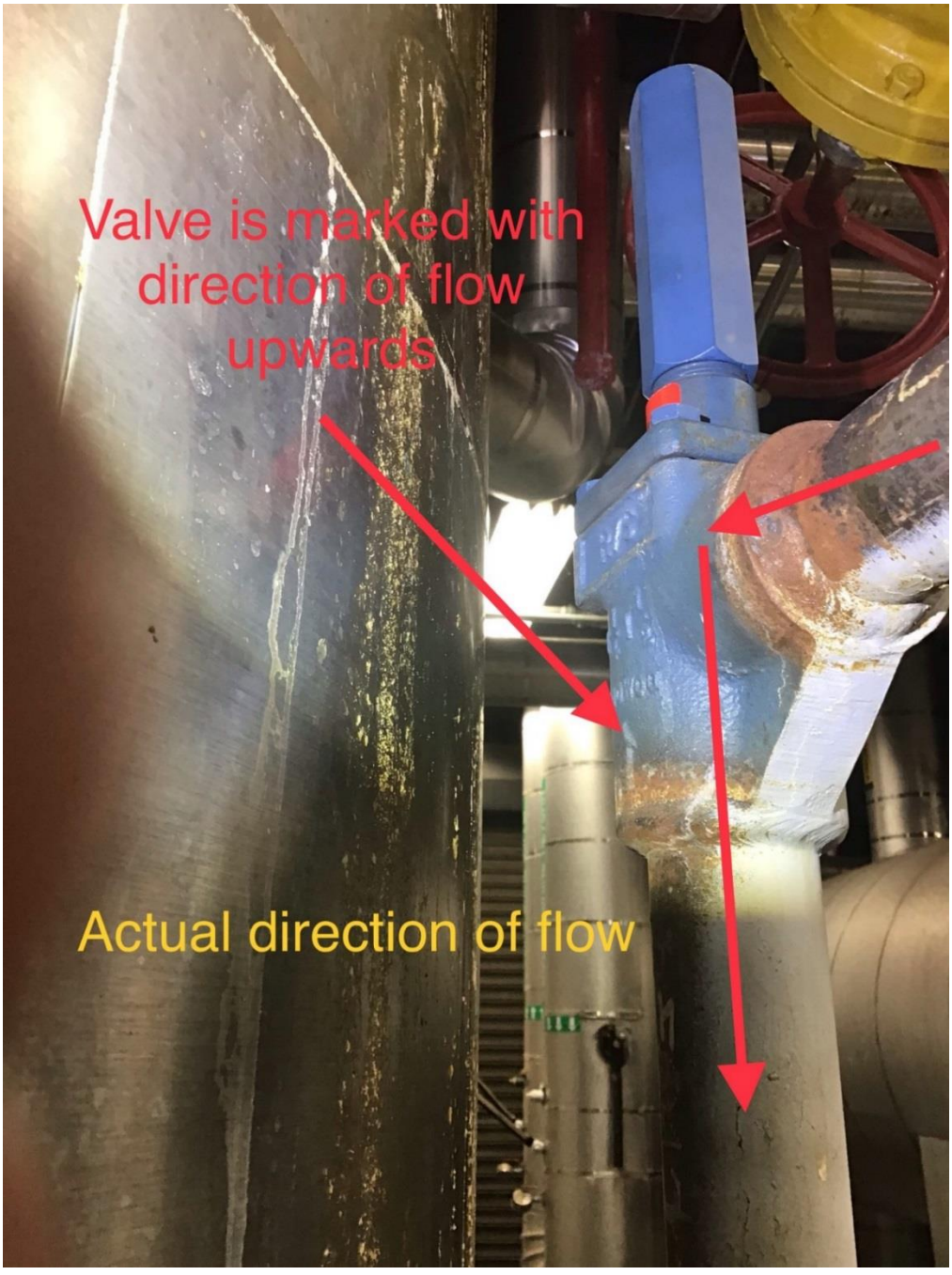
Picture 5: Assembly of stem-plug with valve bonnet – 1/1/2 inch shut off Ammonia Refrigeration Valve **(note: exemplar only)**



Picture 6: Bonnet and Valve body assembly – 1/1/2 inch shut off Ammonia Refrigeration Valve **(note: exemplar only)**



Picture 7: 1/1/2 inch shut off Ammonia Refrigeration Valve socket welded to piping. (Note: the vessel shown here in background is the inter-cooler V3).



Picture 8: Direction of flow on Valve Vs actual flow direction – 180 degree apart. (Note: body shown was involved in incident. Stem/bonnet shown is newly installed after incident).